FIG. 1

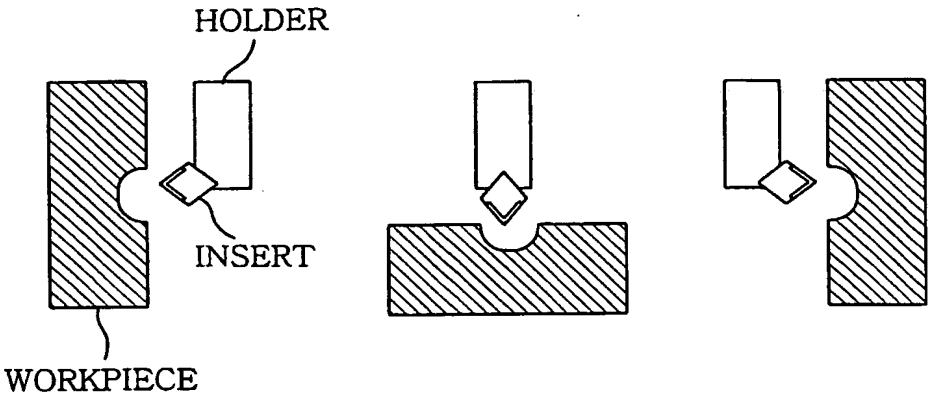


FIG. 2A

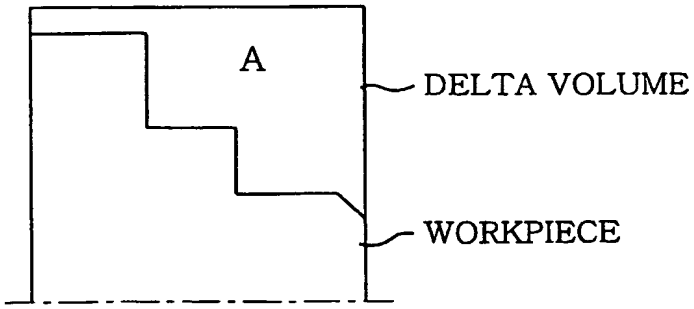


FIG. 2B

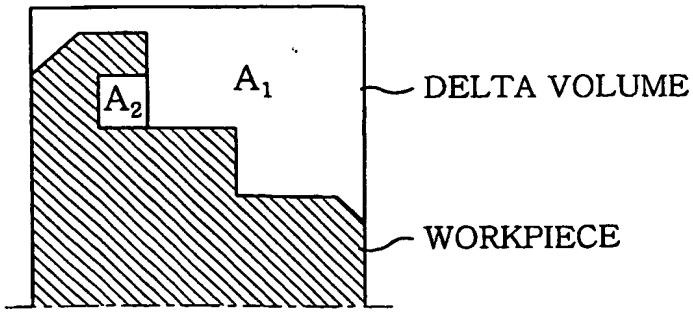
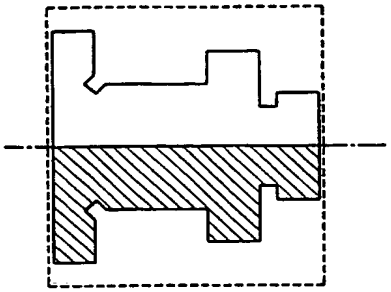
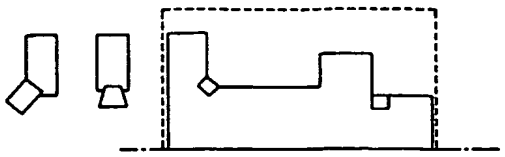


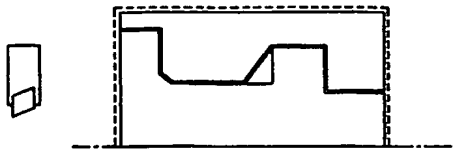
FIG.3



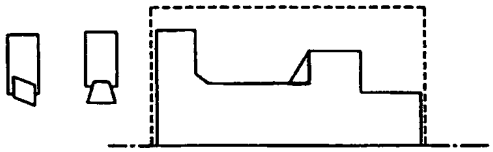
(a) PART



(b) INHERENT DELTA VOLUME

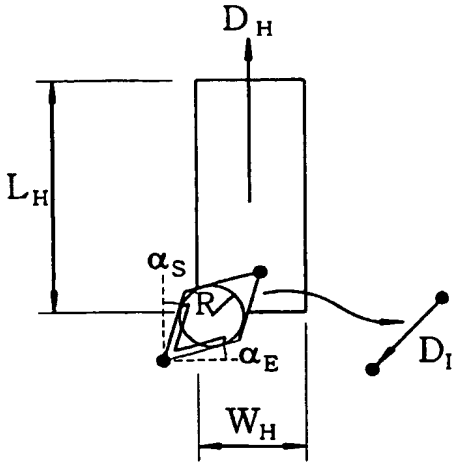


(c) PRIMARY DELTA VOLUME

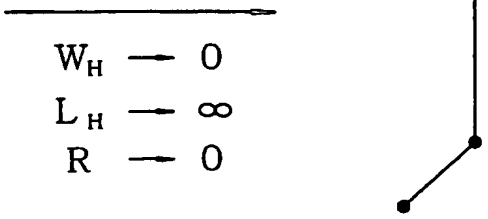


(c) UNCUT DELTA VOLUME

FIG.4



(a) TURNING TOOL



(b) ABSTRACT TURNING TOOL

D_H : HOLDER DIRECTION	R : NOSE RADIUS
L_H : HOLDER LENGTH	α_S : SIDE CUTTING EDGE ANGLE
W_H : HOLDER WIDTH	α_E : END CUTTING EDGE ANGLE
D_I : INSERT DIRECTION	

FIG.5

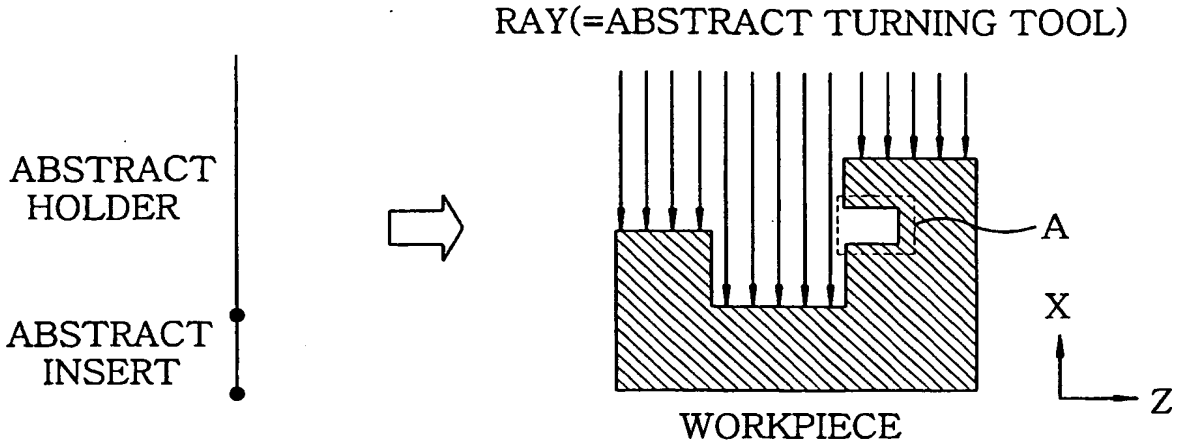
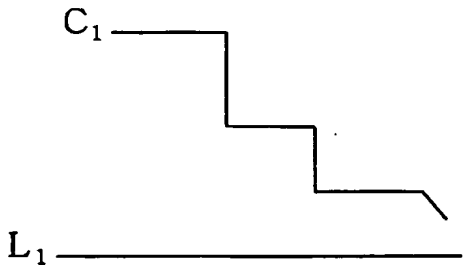
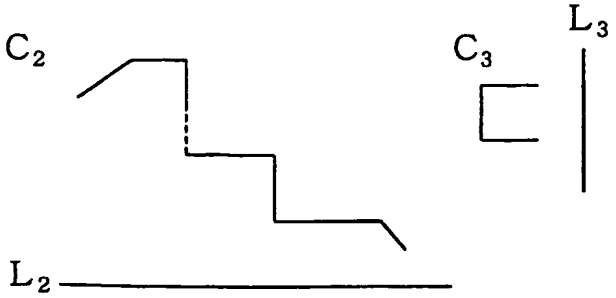


FIG.6A



(a) PROFILE OF FIG.2A

FIG.6B



(a) PROFILE OF FIG.2B

FIG. 7A

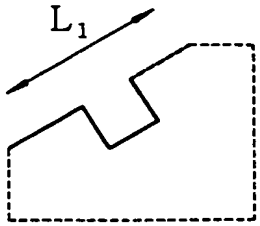


FIG. 7B

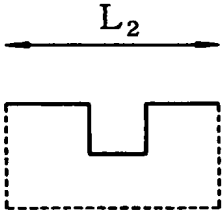


FIG. 7C

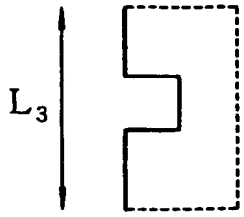


FIG.8

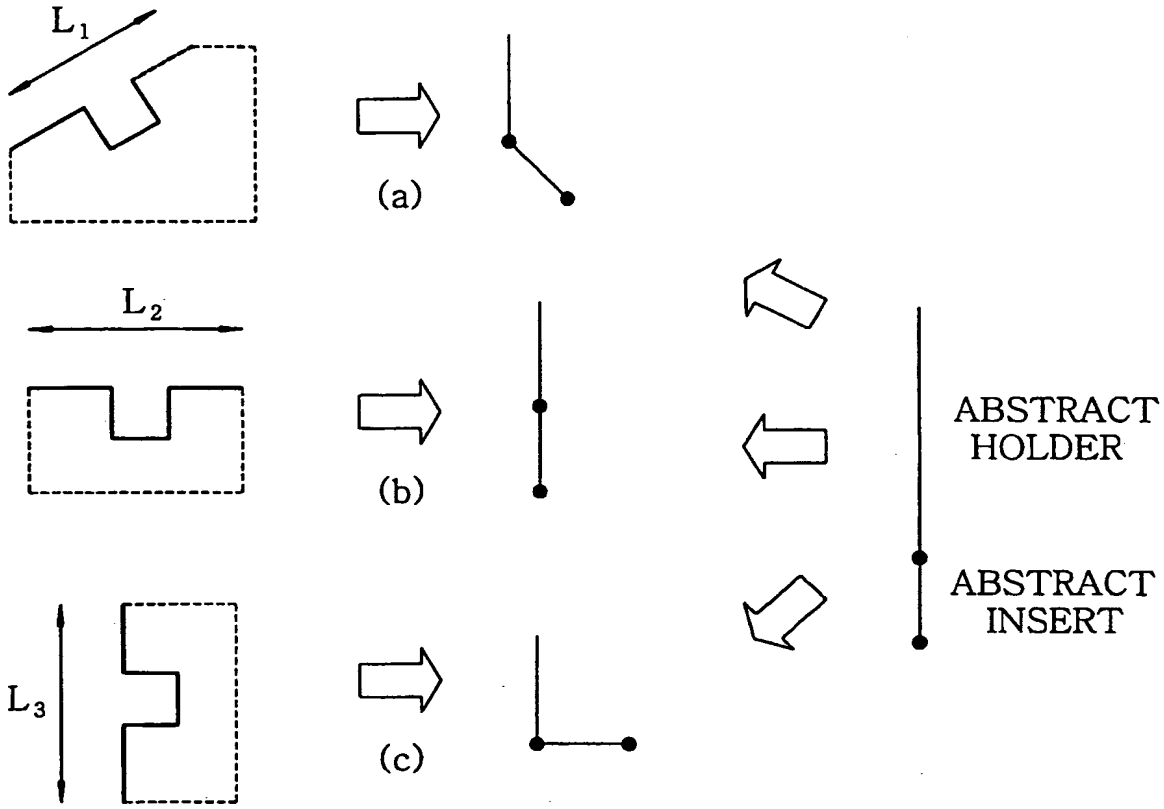


FIG. 9A

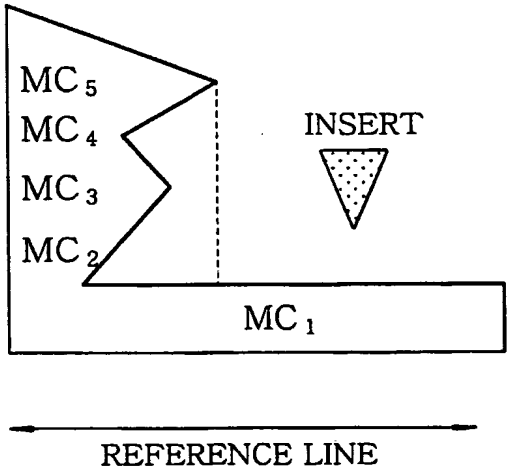

MC 5
MC 4
MC 3
MC 2
MC 1
INSERT
REFERENCE LINE

FIG. 9B

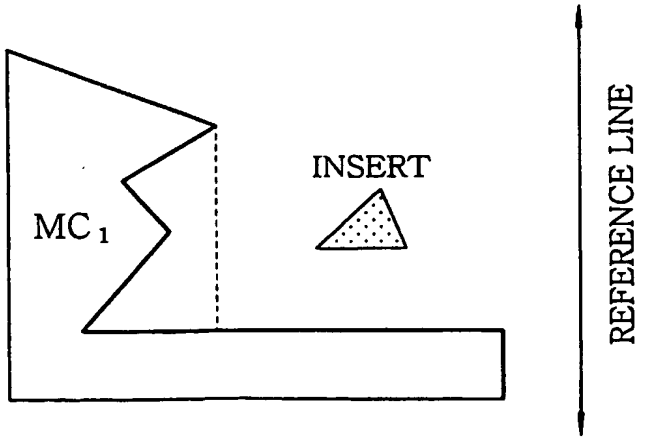
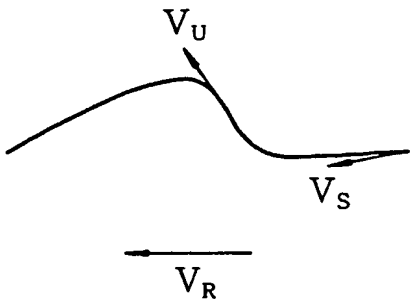
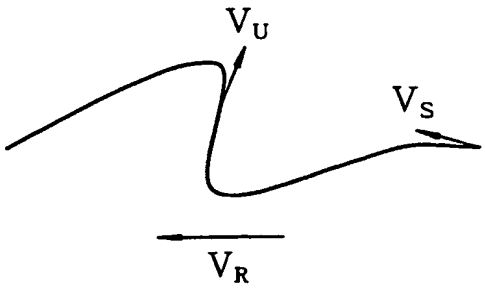

MC 1
INSERT
REFERENCE LINE

FIG. 10A



$$\text{SIGN}(V_S \bullet V_R) = \text{SIGN}(V_U \bullet V_R)$$

FIG. 10B



$$\text{SIGN}(V_S \bullet V_R) \neq \text{SIGN}(V_U \bullet V_R)$$

FIG. 11A

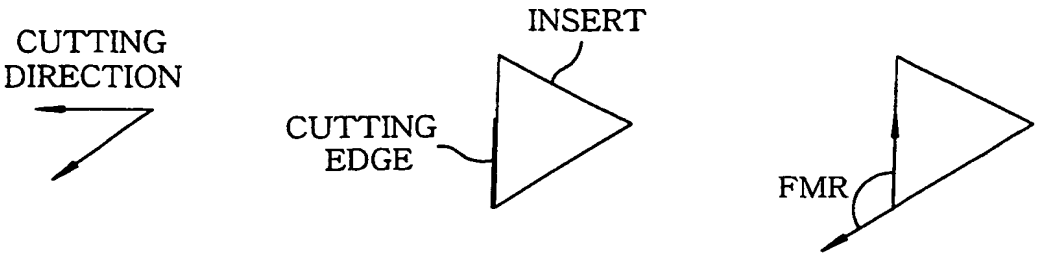


FIG. 11B

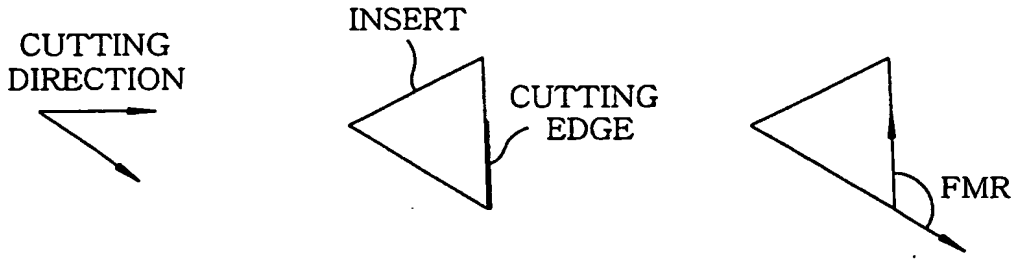


FIG. 11C

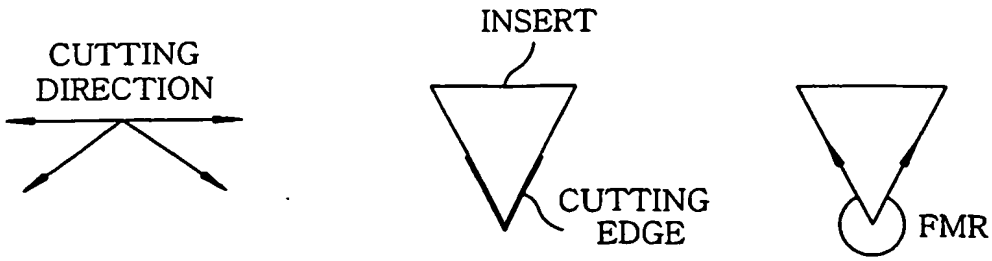
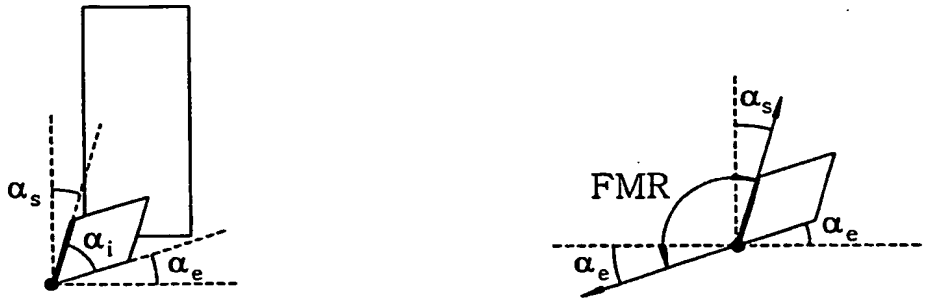
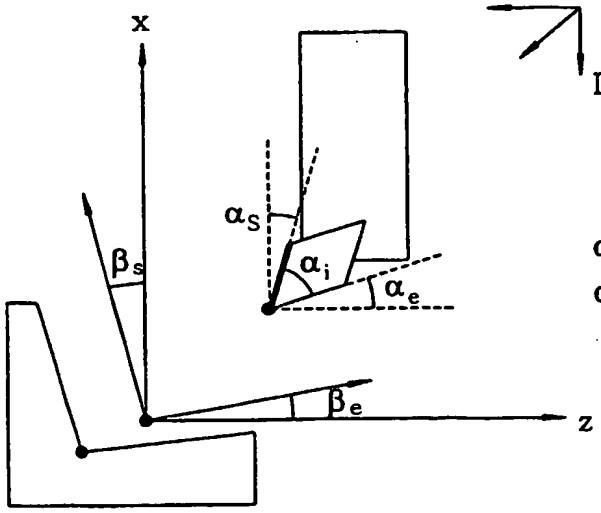


FIG. 12A



α_i : INSERT ANGLE
α_S : SIDE CUTTING EDGE ANGLE
α_e : END CUTTING EDGE ANGLE

FIG. 12B



CUTTING DIRECTION

β_s : WORKPIECE SIDE ANGLE
β_e : WORKPIECE BOTTOM ANGLE

α_e , β_e : CCW WITH RESPECT TO Z-AXIS
α_s , β_s : CW WITH RESPECT TO X-AXIS

$(\alpha_e > \beta_e)$ AND $(90° - \alpha_s < 90° - \beta_s)$

FMR : $[90° - \alpha_s, 180° + \alpha_e]$

FIG. 13A

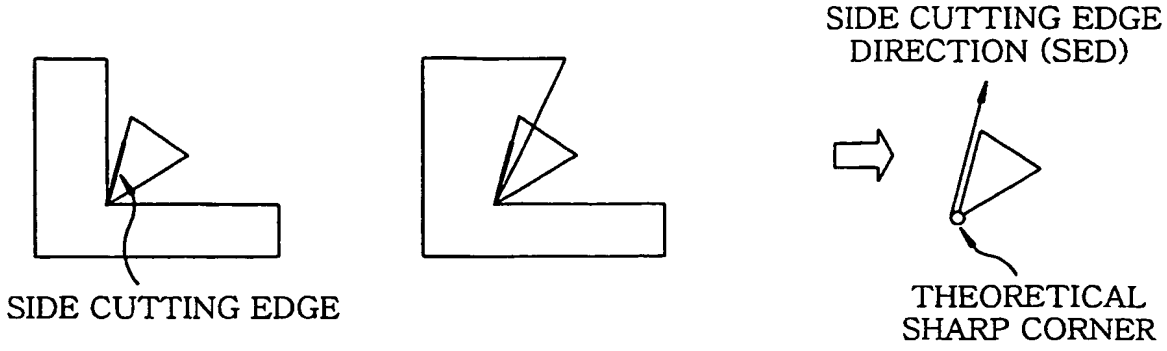


FIG. 13B

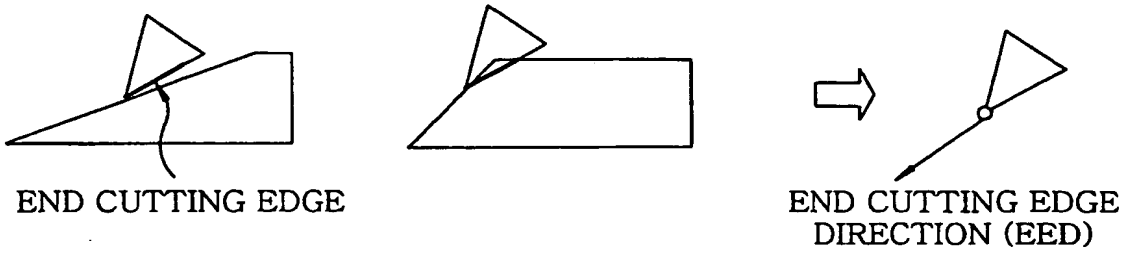


FIG. 14

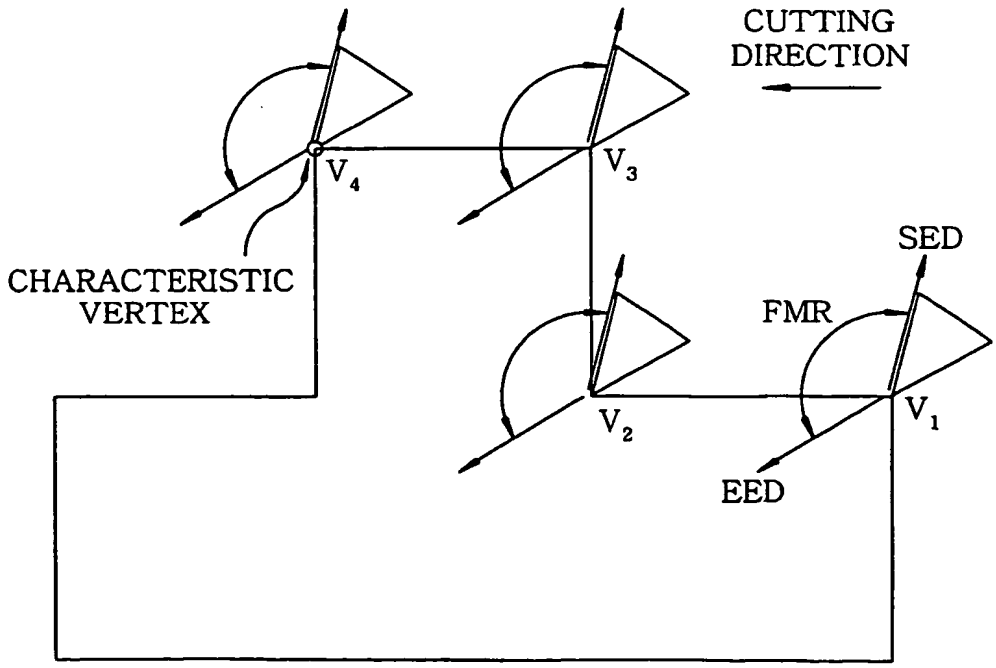


FIG. 15A

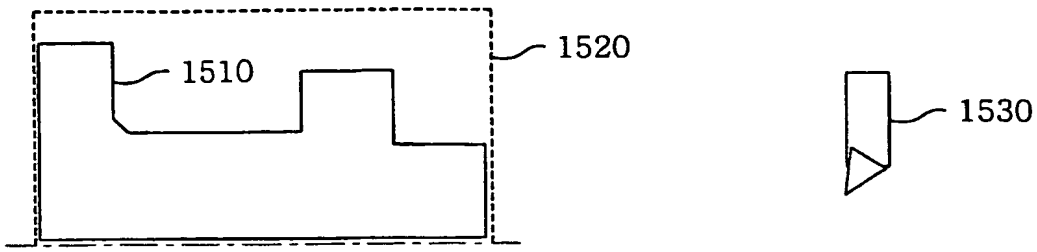


FIG. 15B

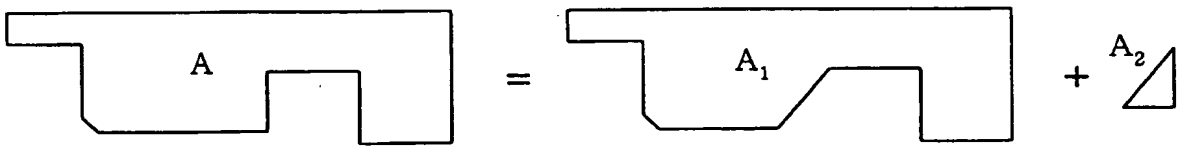


FIG. 16

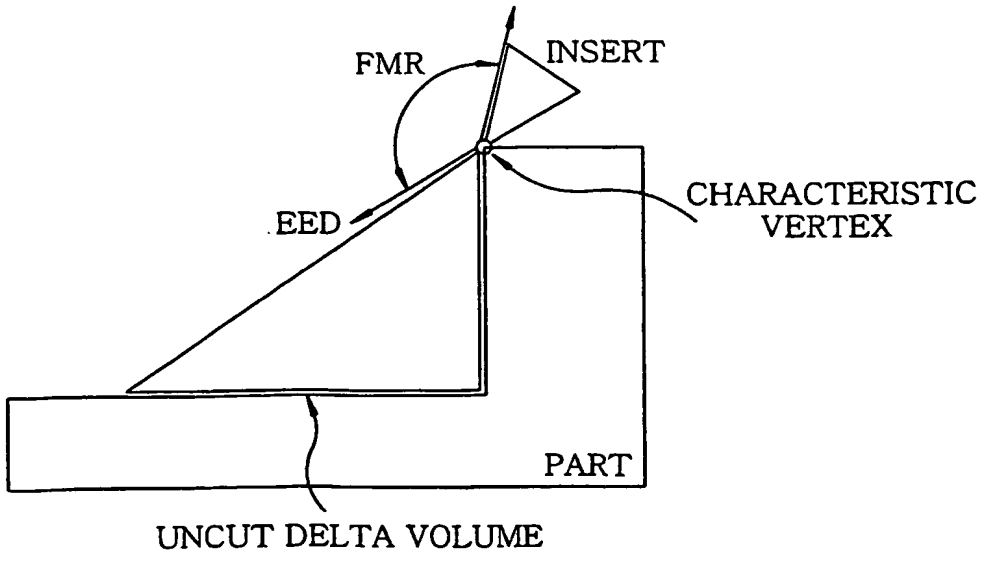


FIG. 17

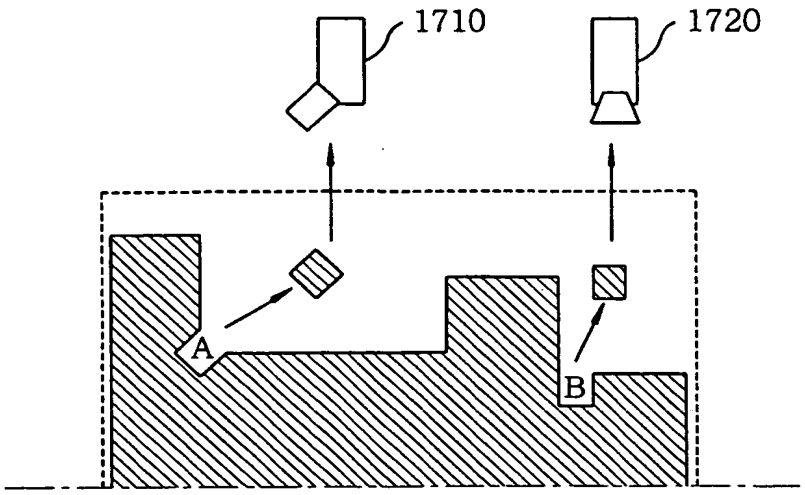


FIG. 18A

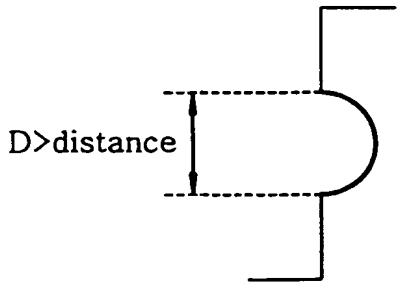


FIG. 18B

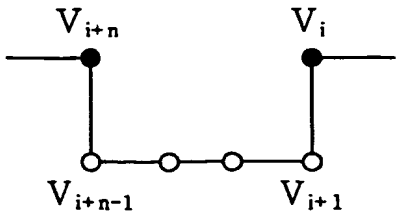


FIG. 19A

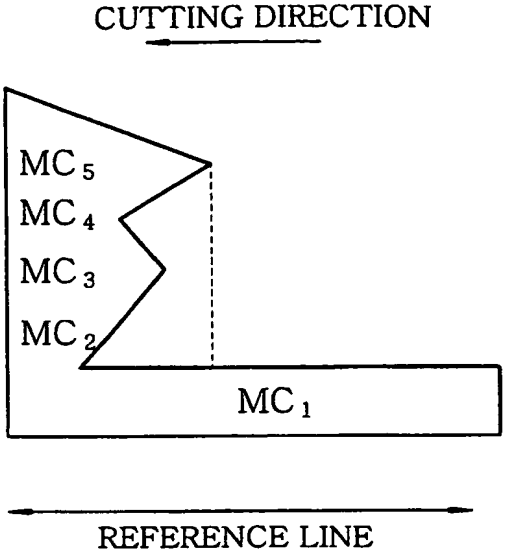


FIG. 19B

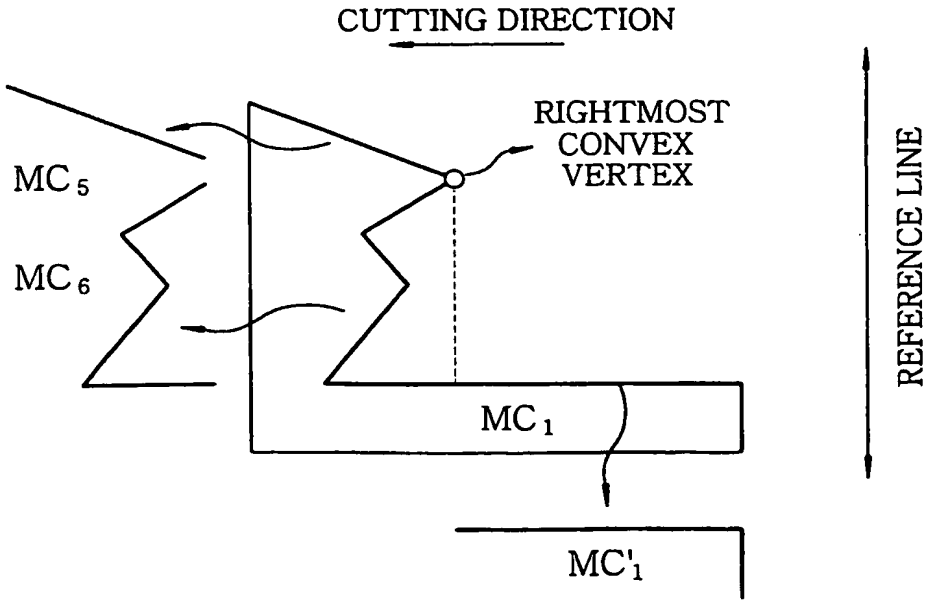


FIG.20A

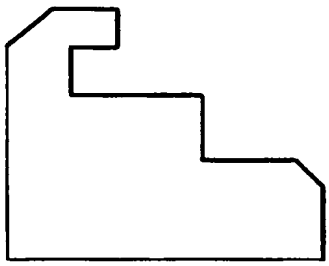


FIG.20B

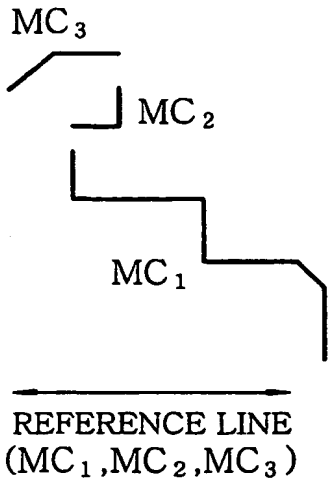


FIG.20C

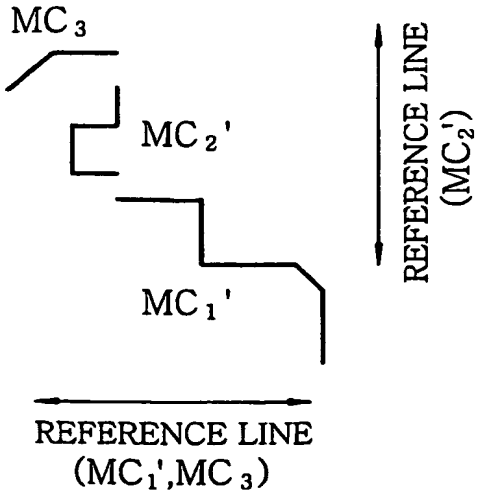


FIG.21A

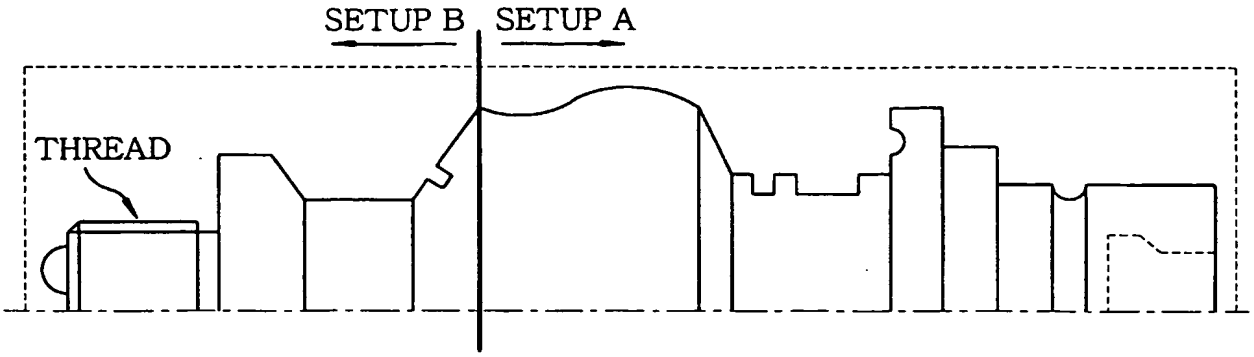


FIG.21B

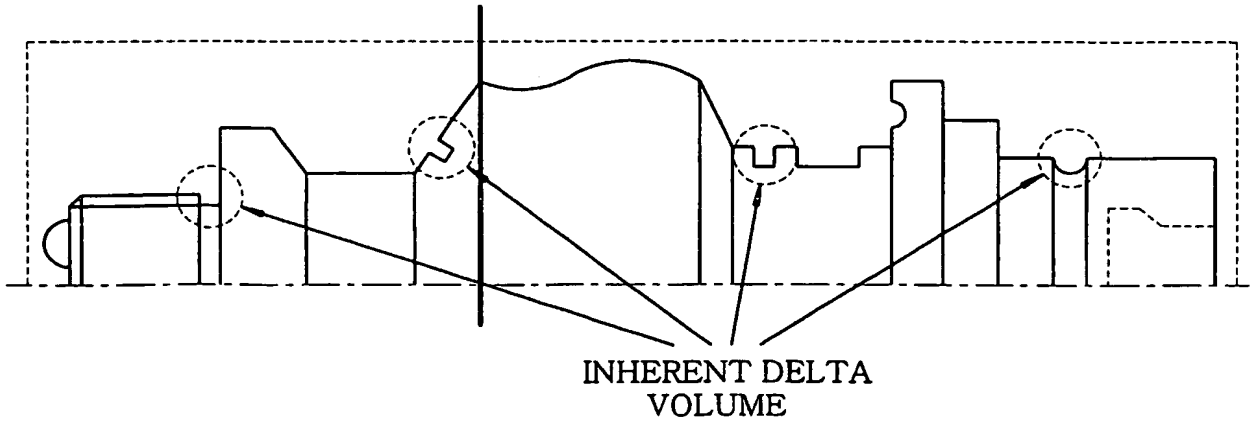


FIG.21C

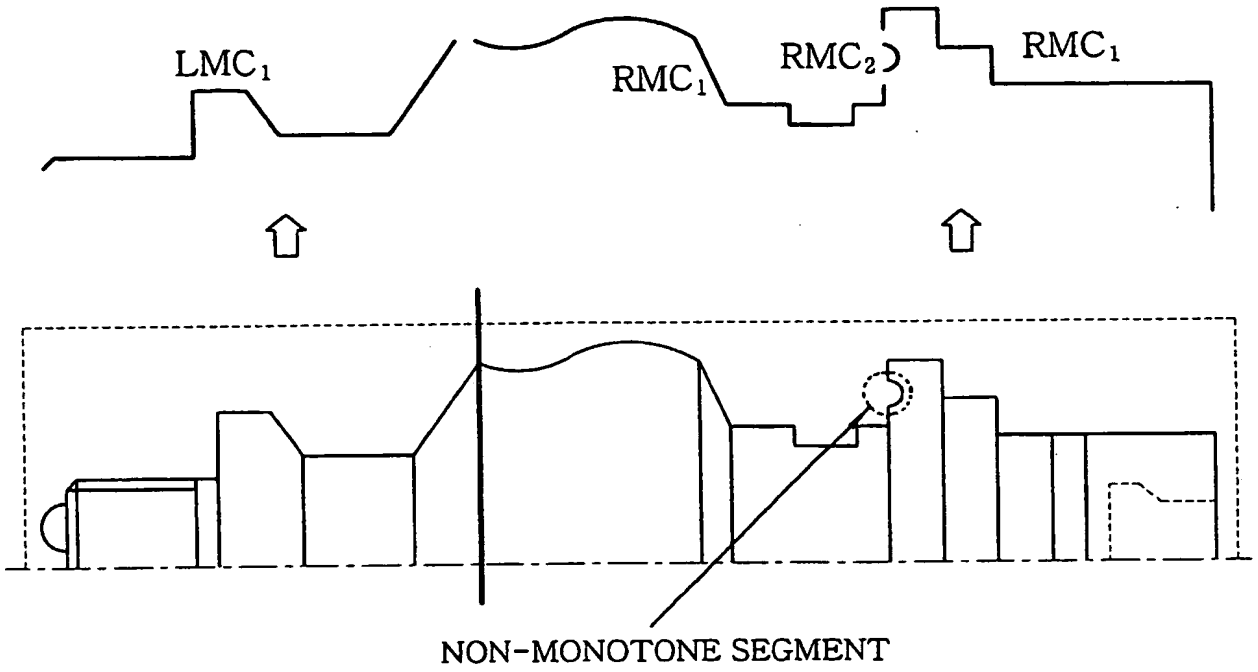


FIG.21D

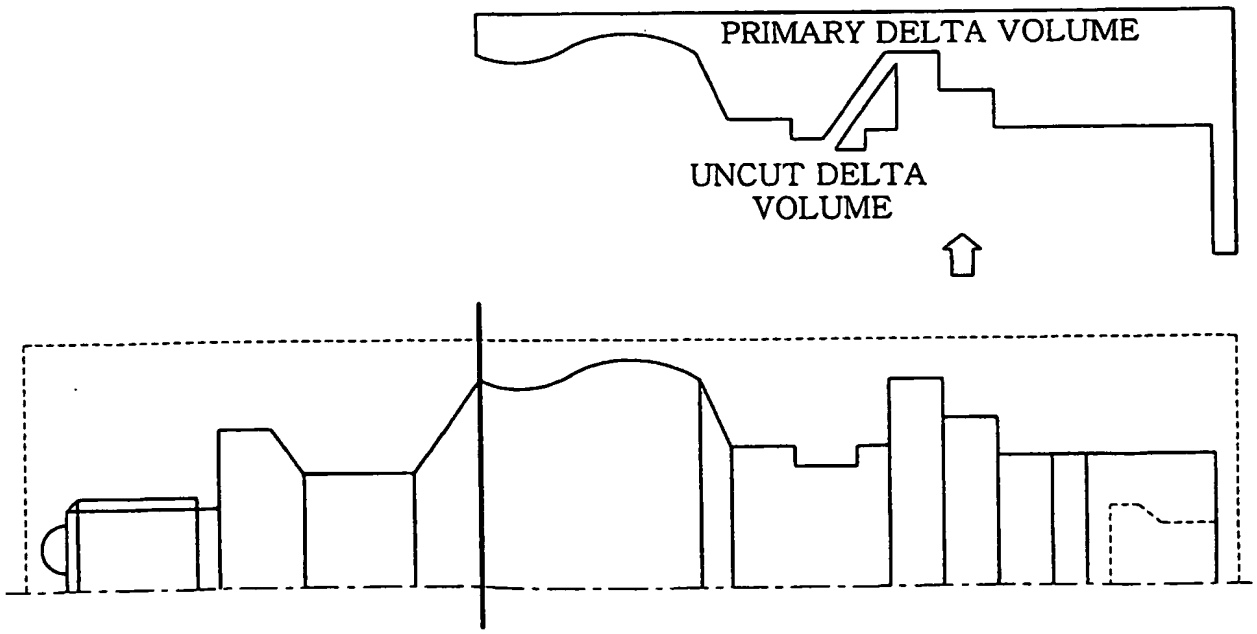


FIG.22

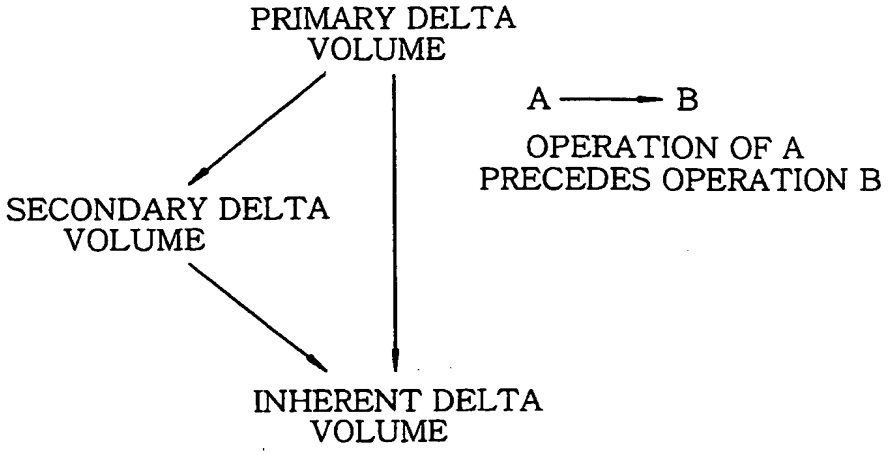


FIG.23A

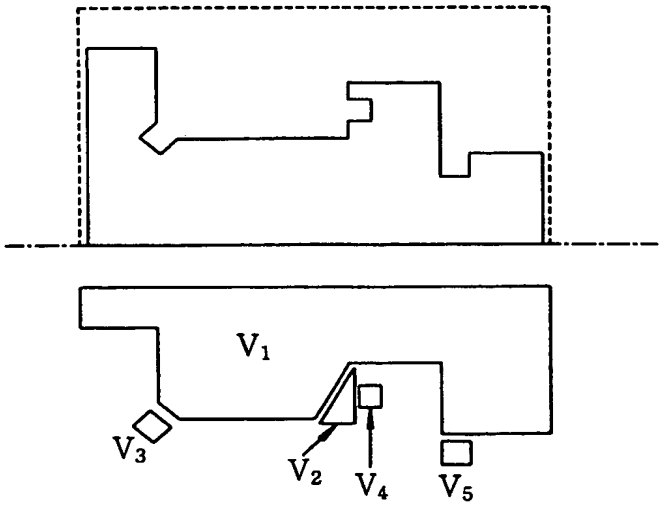


FIG.23B

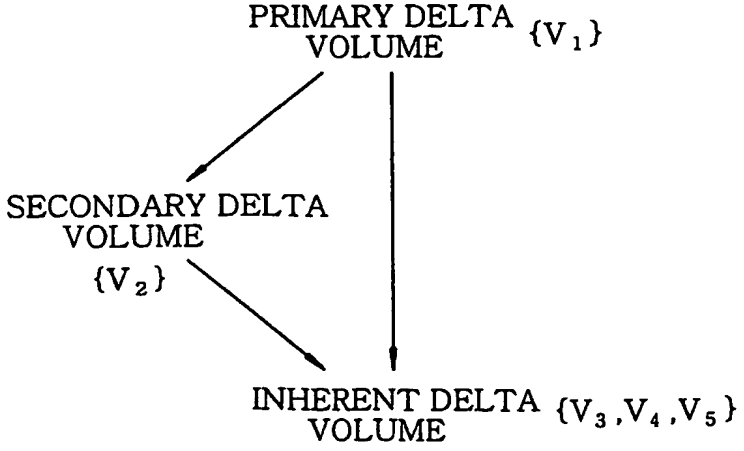


FIG.24

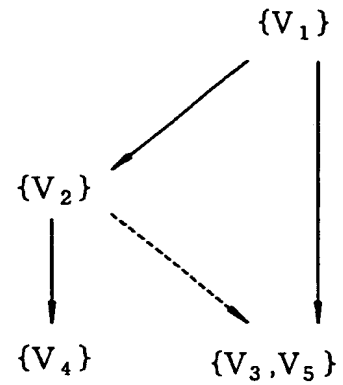


FIG.25A

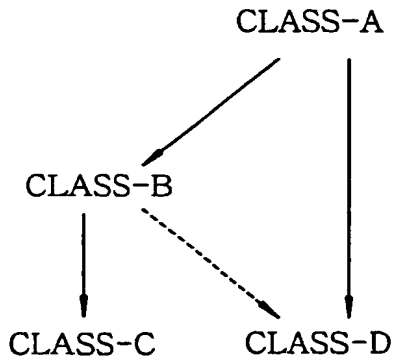


FIG.25B

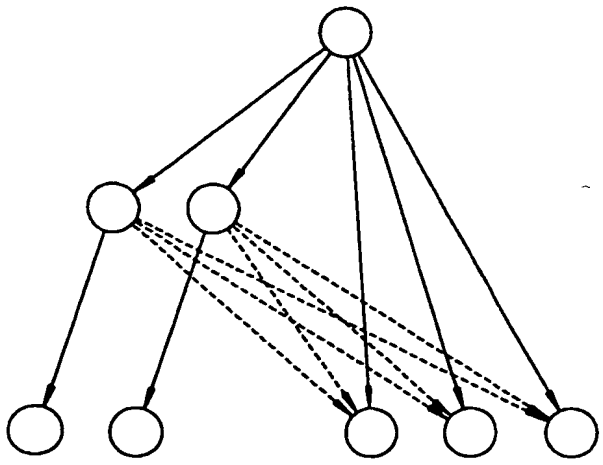


FIG.26A

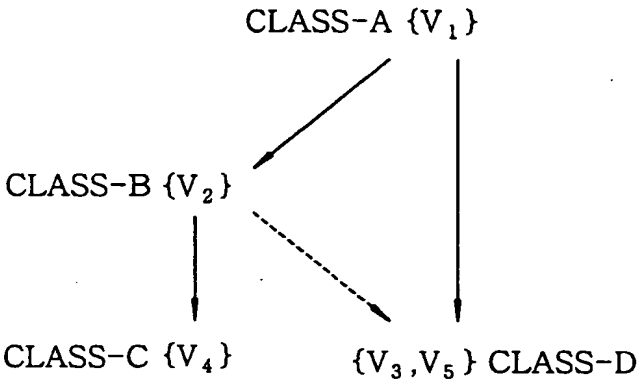


FIG.26B

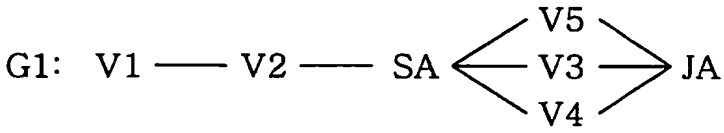


FIG.26C

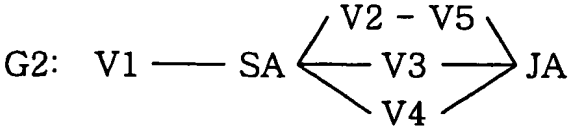


FIG.26D

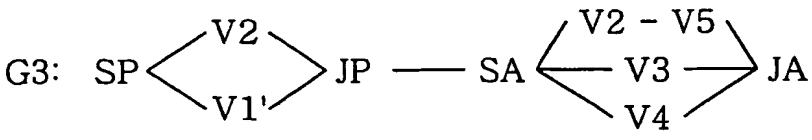


FIG.26E

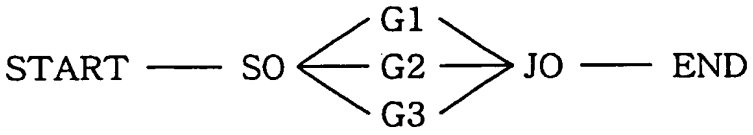


FIG.27A

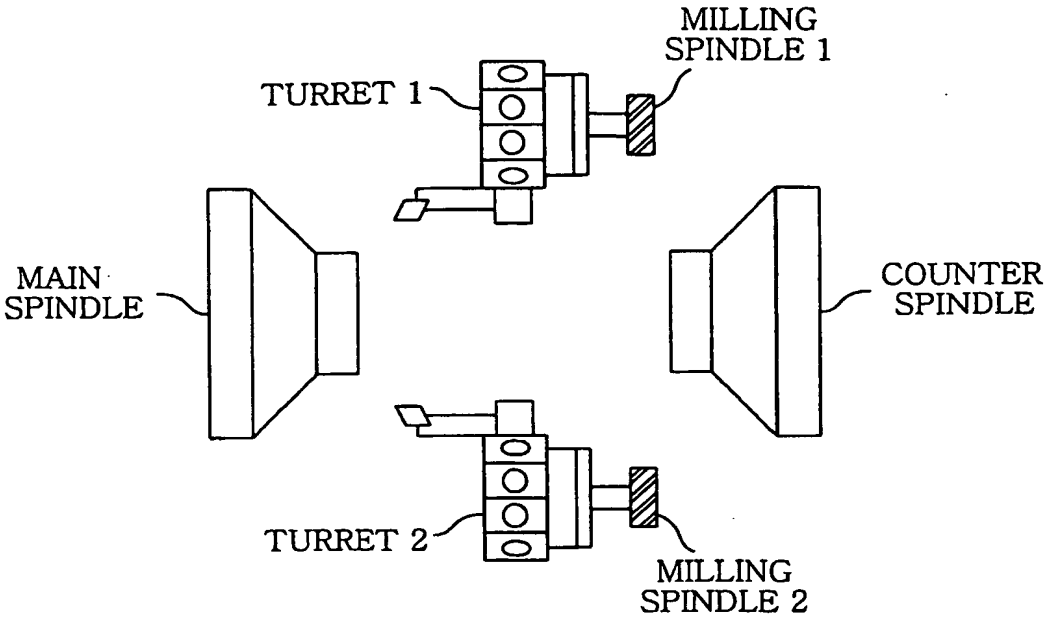


FIG.27B

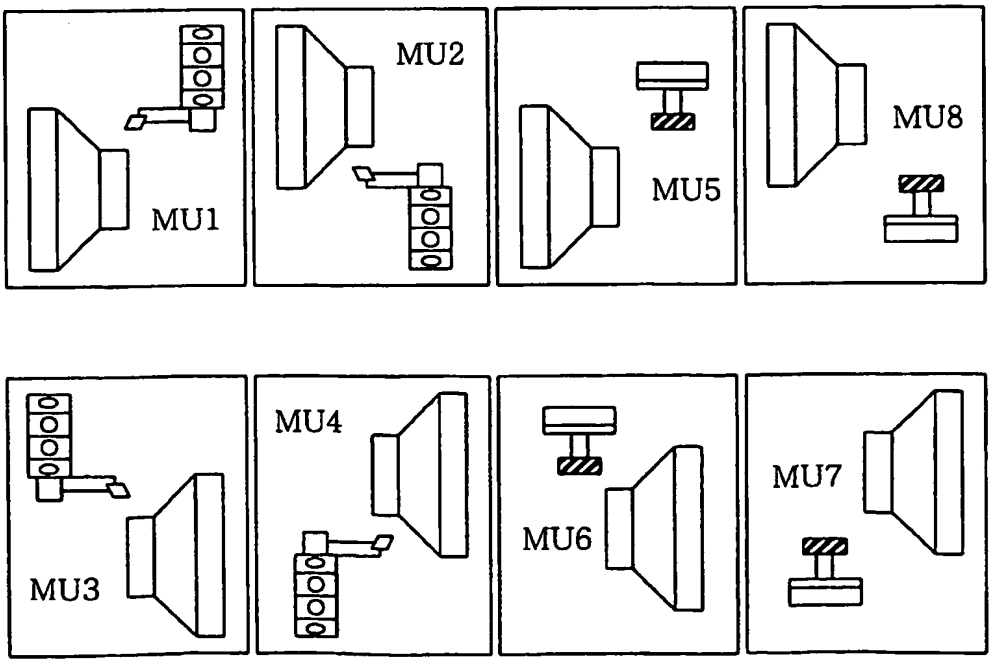


FIG.28

OPERATION #	FEATURE #	Op.DESCRIPTION	PREDECESSOR	TIME
11	1	FACING	42	5
12	2	ROUGH CONTOURING	11	10
13	2	FINISH CONTOURING	12	8
14	3	GROOVING	41 or 42	2
15	4	GROOVING	41 or 42	2
16	5	ROUGH CONTOURING	18	15
17	5	FINISH CONTOURING	16	10
18	6	FACING	41	5
21	7	INNER CONTOURING	42	5
31-1,31-2	8,9	MILLING	13	8x2
33	10	MILLING	41 or 42	3
32-1,32-2, 32-3,32-4	12,13,14,15	MILLING	17	3x4
22	16	GROOVING	13	2
23	17	GROOVING	13	2
24	18	GROOVING	17	2
25	19	GROOVING	17	2
41	NONE	CLAMPING (SETUP)	NONE	5
42	NONE	CLAMPING (SETUP)	NONE	5

FIG.29A

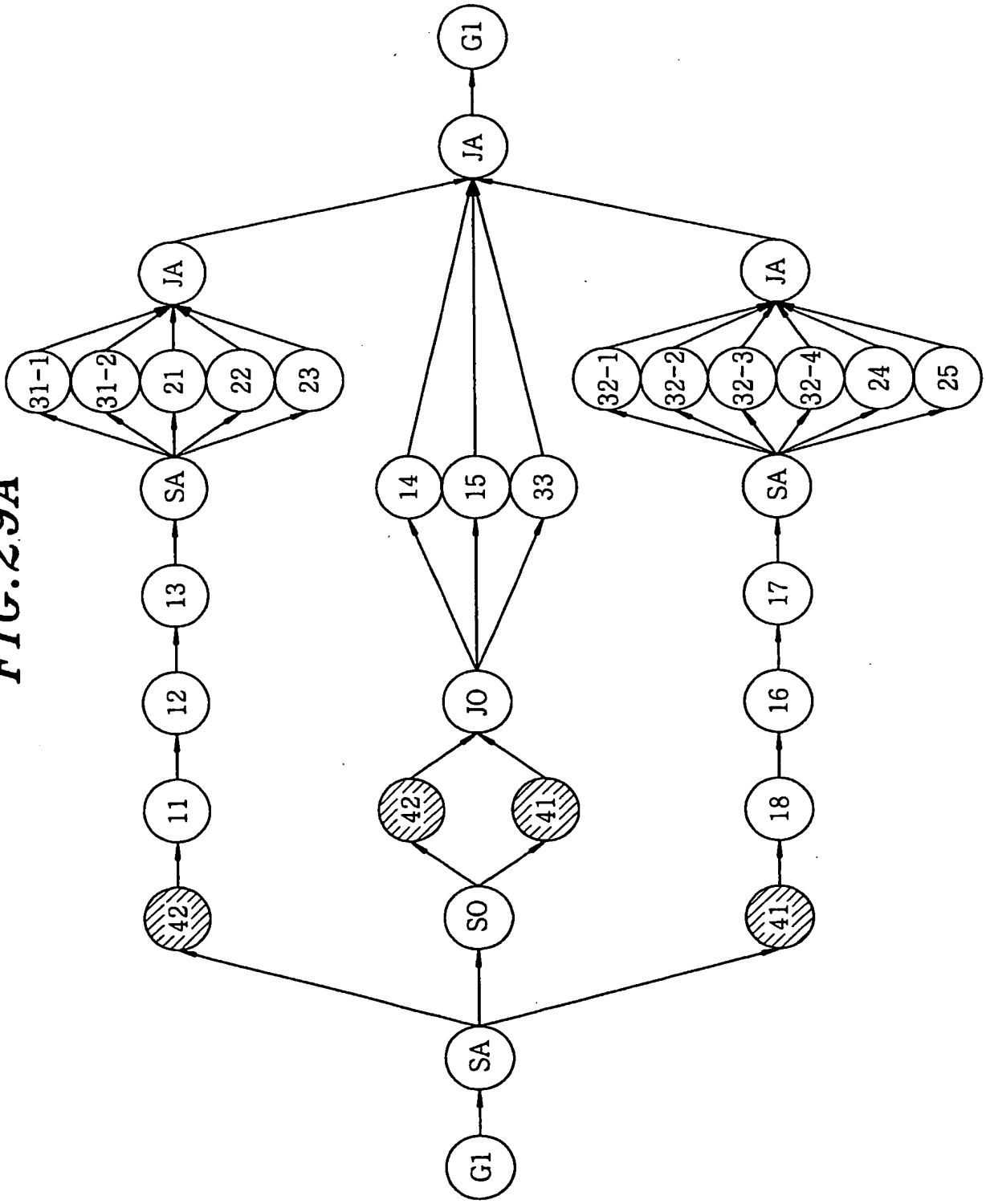

G1
JA
JA
JA
31-1
31-2
21
22
23
14
15
33
32-1
32-2
32-3
32-4
24
25
SA
SA
13
17
12
JO
16
11
42
41
18
42
SO
41
SA
G1

FIG.29B

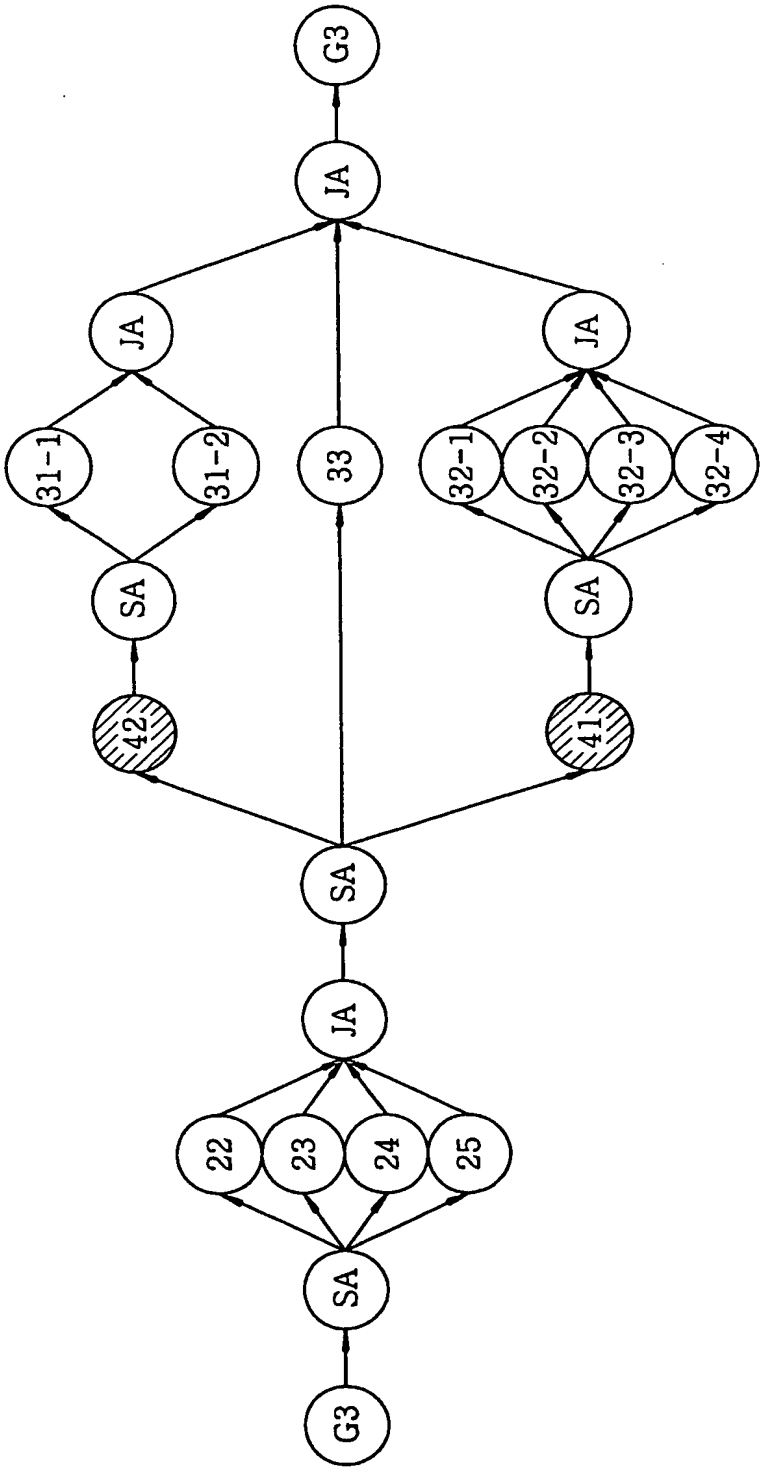

G3
JA
JA
JA
31-1
31-2
33
32-1
32-2
32-3
32-4
SA
SA
42
41
SA
JA
22
23
24
25
SA
G3

FIG.29C

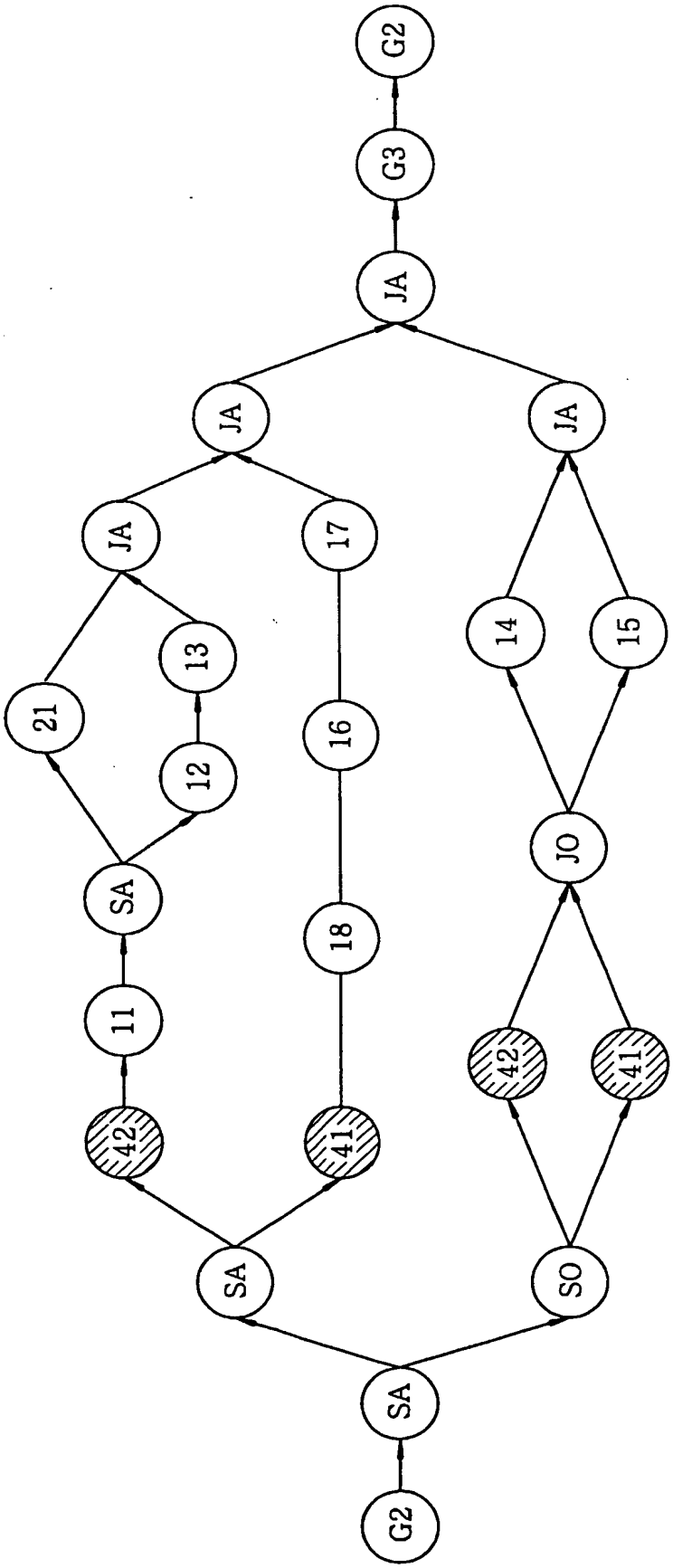

G2
G3
JA
JA
JA
JA
17
14
15
13
21
16
12
JO
SA
18
11
42
41
42
41
SA
SO
SA
G2

FIG.29D

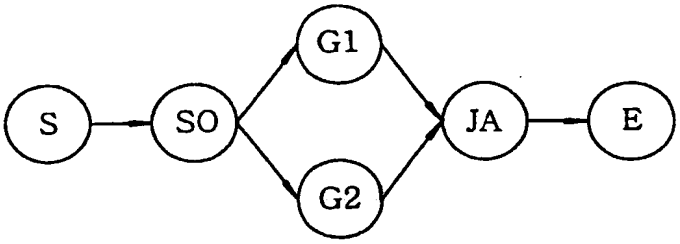


FIG.30

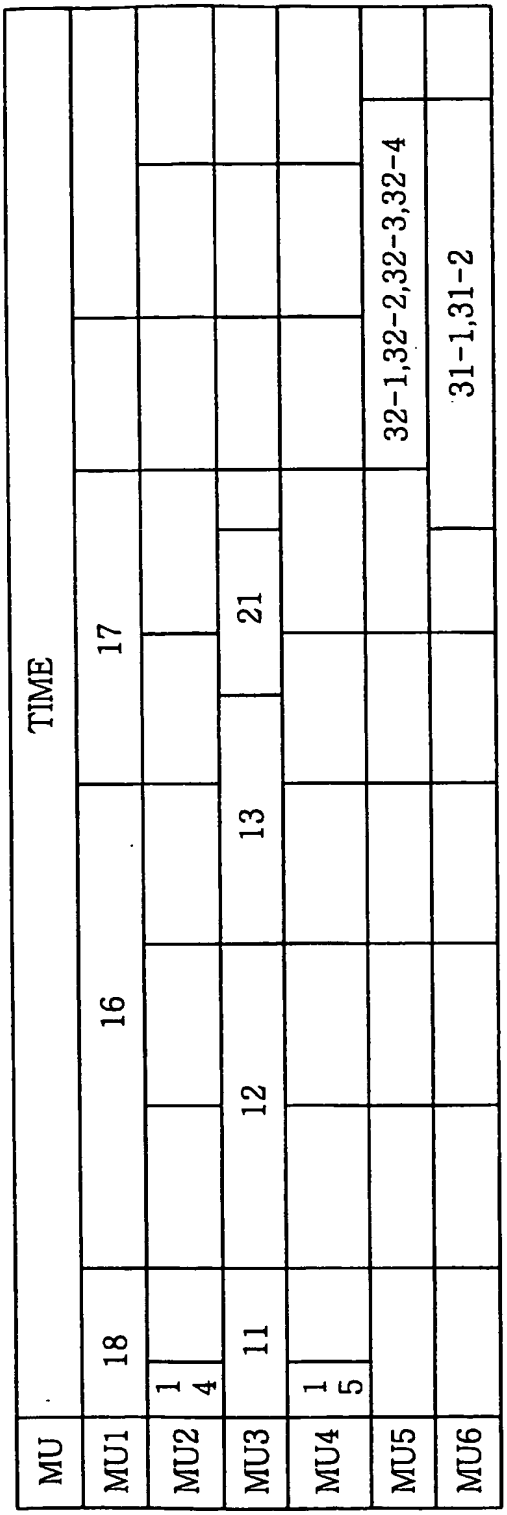

TIME
MU
MU1
MU2
MU3
MU4
MU5
MU6
18
16
17
14
12
13
21
11
15
32-1,32-2,32-3,32-4
31-1,31-2

FIG.31A

TOLERANCE: ± 0.1

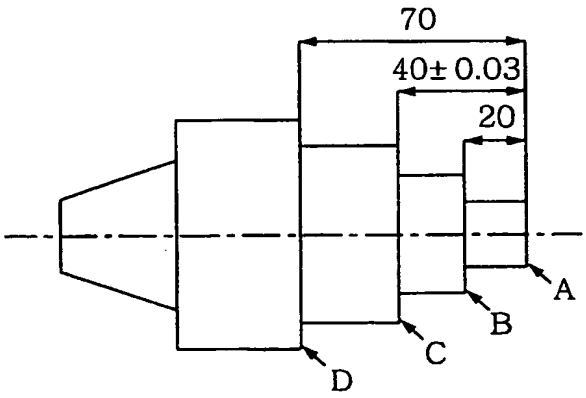


FIG.31B

TOLERANCE: ± 0.1

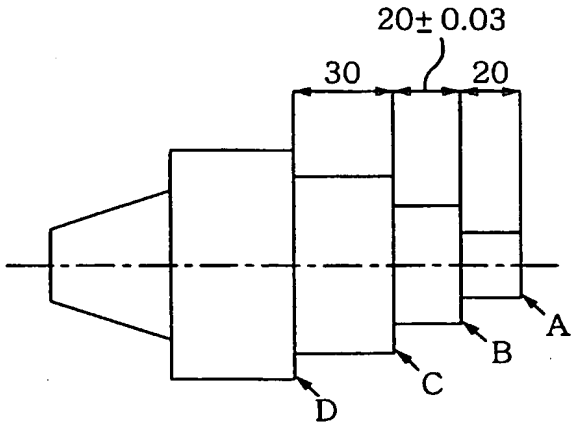


FIG.32

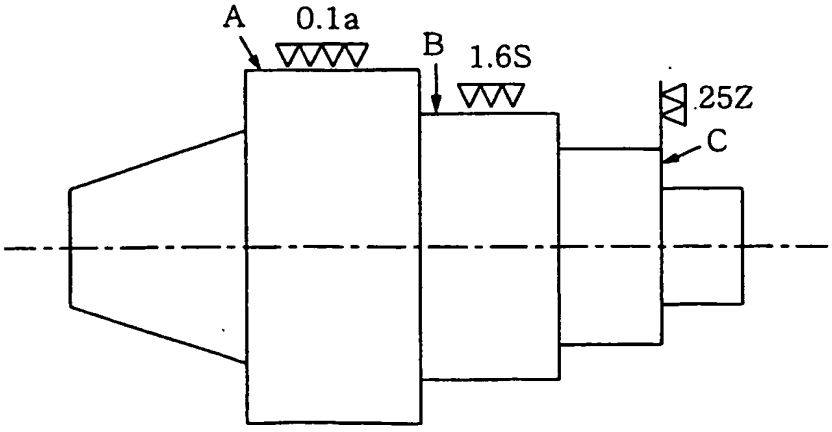
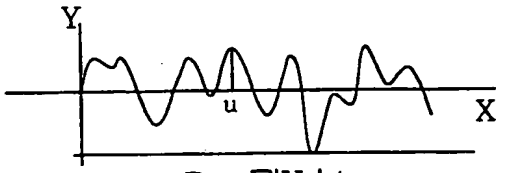
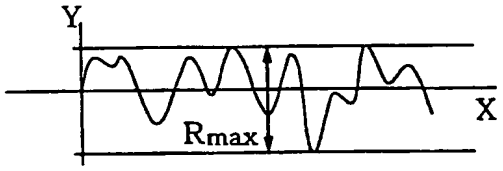


FIG.33

Ra	Rmax	Rz	symbol
0.013a	0.05S	0.05Z	▽▽▽▽
0.025a	0.1S	0.1Z	
0.05a	0.2S	0.2Z	
0.10a	0.4S	0.4Z	
0.20a	0.8S	0.8Z	
0.40a	1.6S	1.6Z	▽▽▽
0.80a	3.2S	3.2Z	
1.6a	6.3S	6.3Z	
3.2a	12.5S	12.5Z	▽▽
6.3a	25S	25Z	
12.5a	50S	50Z	▽
25a	100S	100Z	



$R_a = \Sigma|Y_u| / n$



R_z=(sum of 5 maximum Ys − sum of 5 minimum Ys)/5

FIG.34

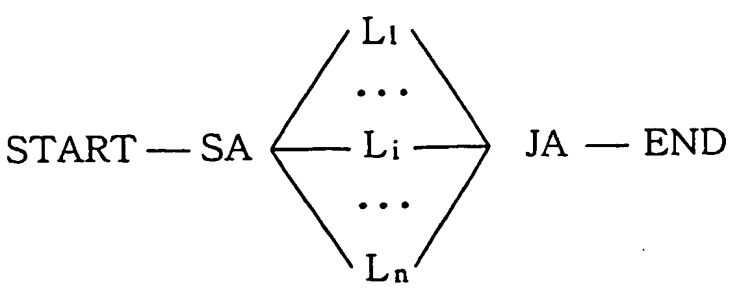


FIG.35A

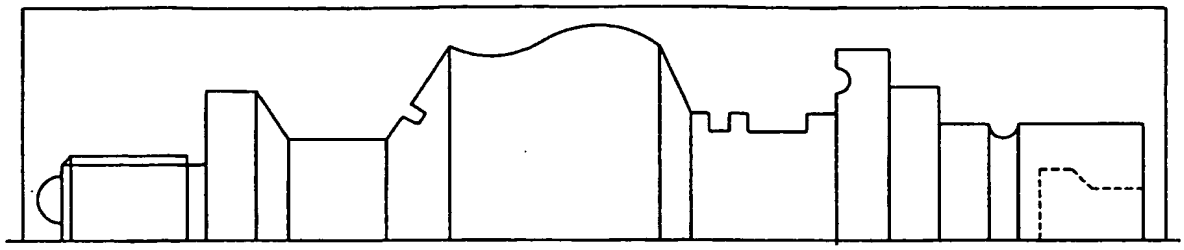


FIG.35B

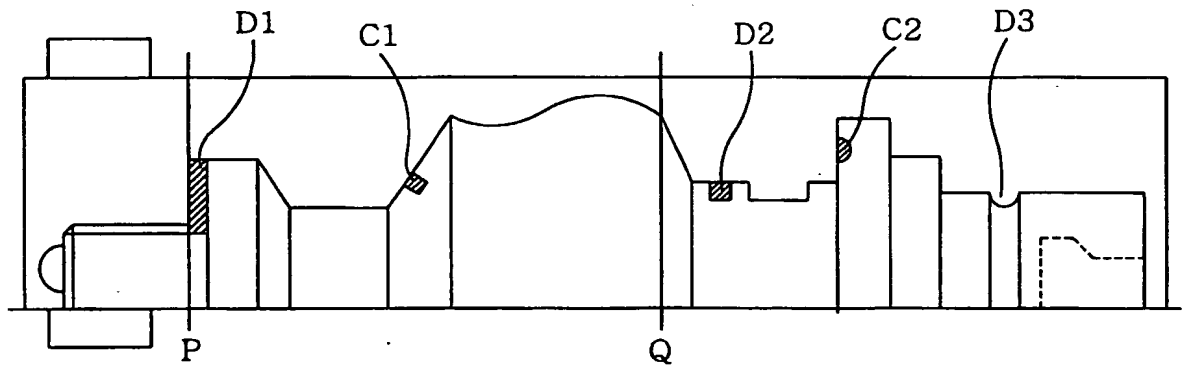


FIG.35C

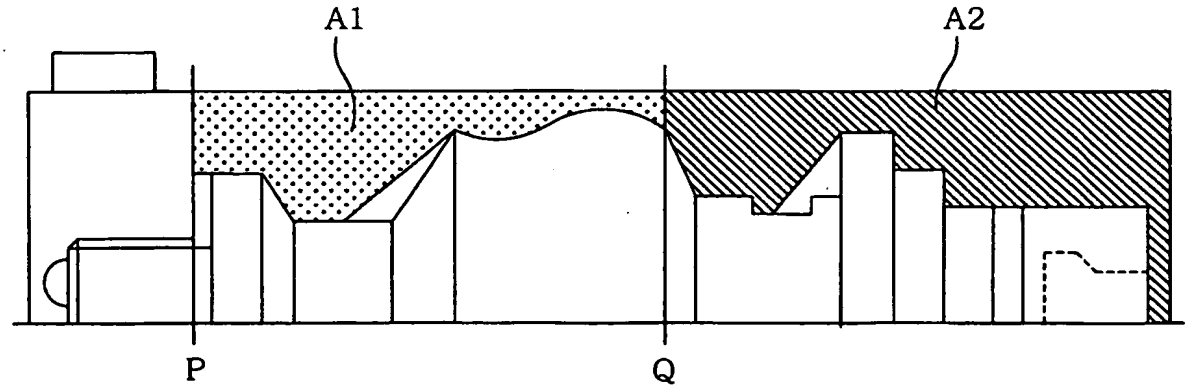


FIG.35D

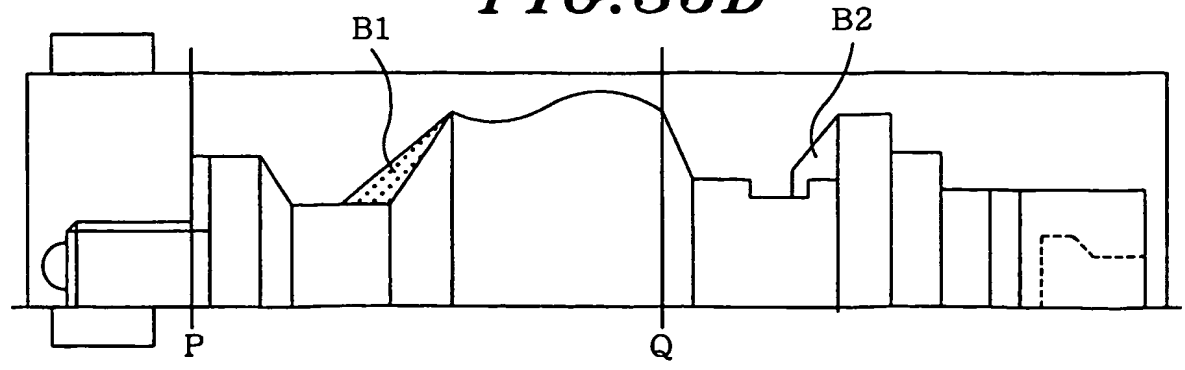


FIG.35E

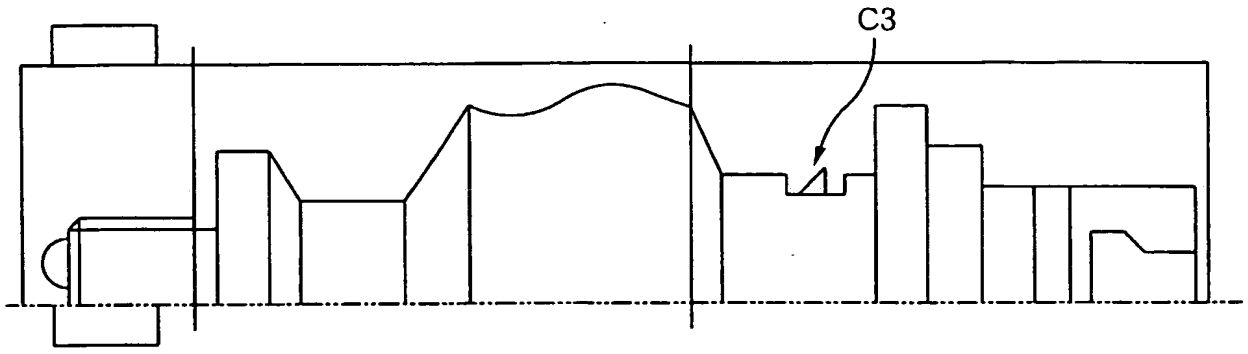


FIG.35F

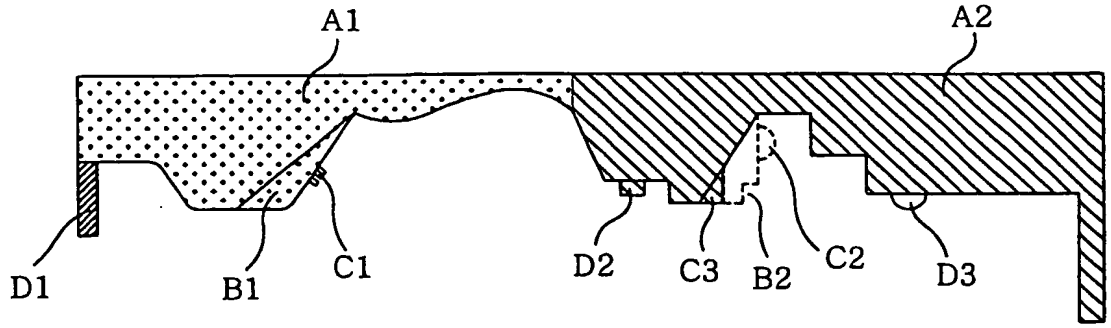


FIG.36A

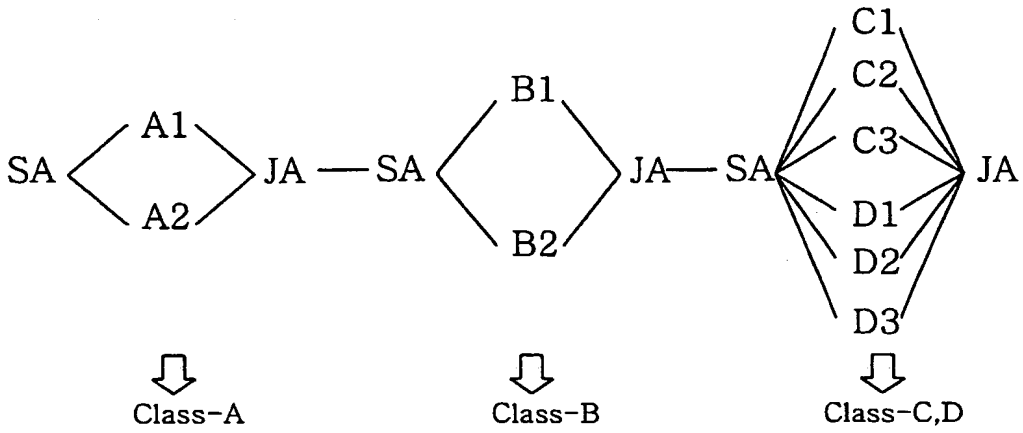


FIG.36B

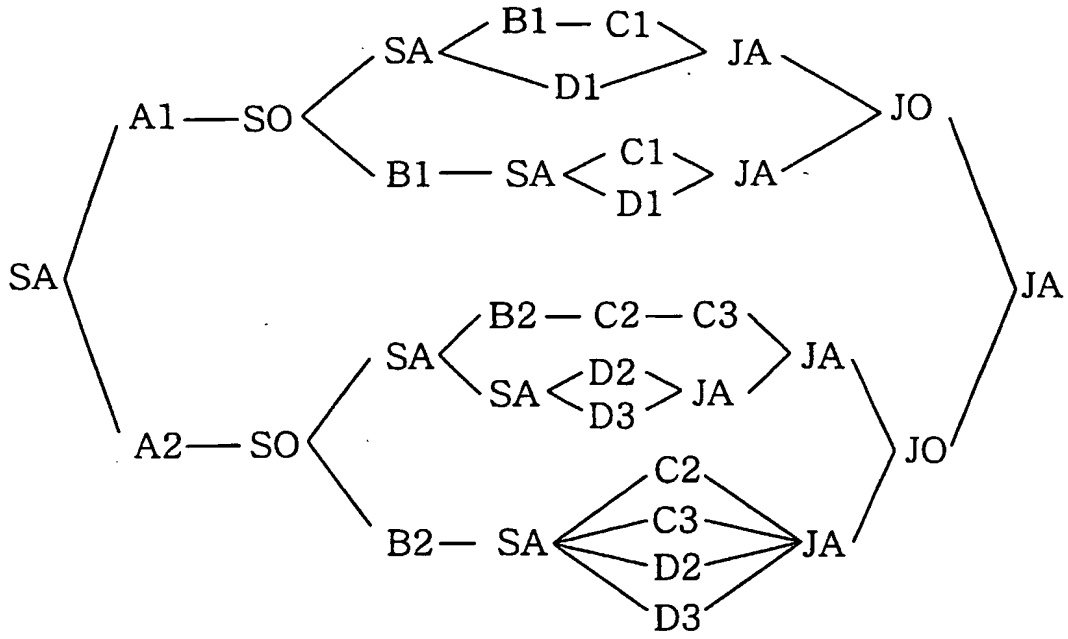


FIG.36C

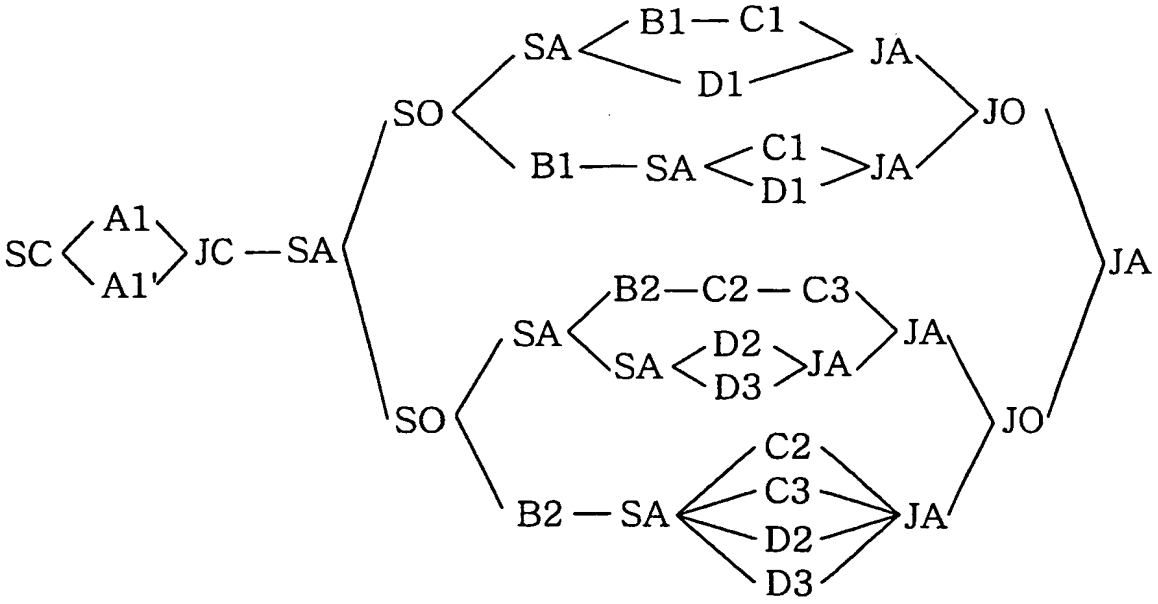


FIG.36D

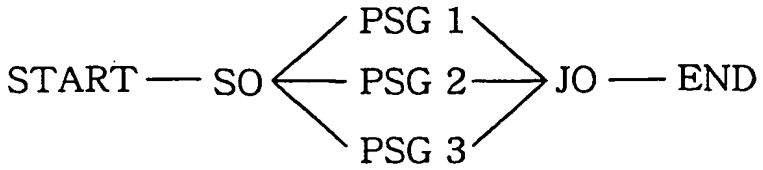


FIG.37

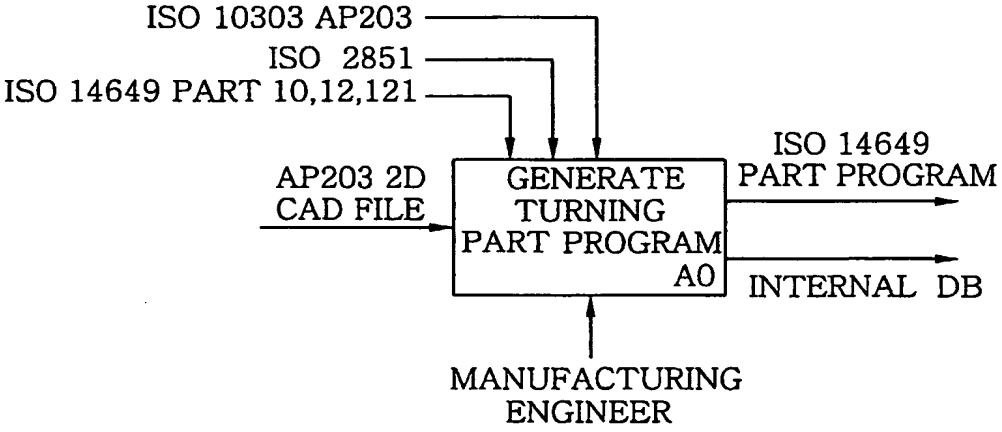

ISO 10303 AP203
ISO 2851
ISO 14649 PART 10,12,121
AP203 2D CAD FILE
GENERATE TURNING PART PROGRAM A0
ISO 14649 PART PROGRAM
INTERNAL DB
MANUFACTURING ENGINEER

FIG.38

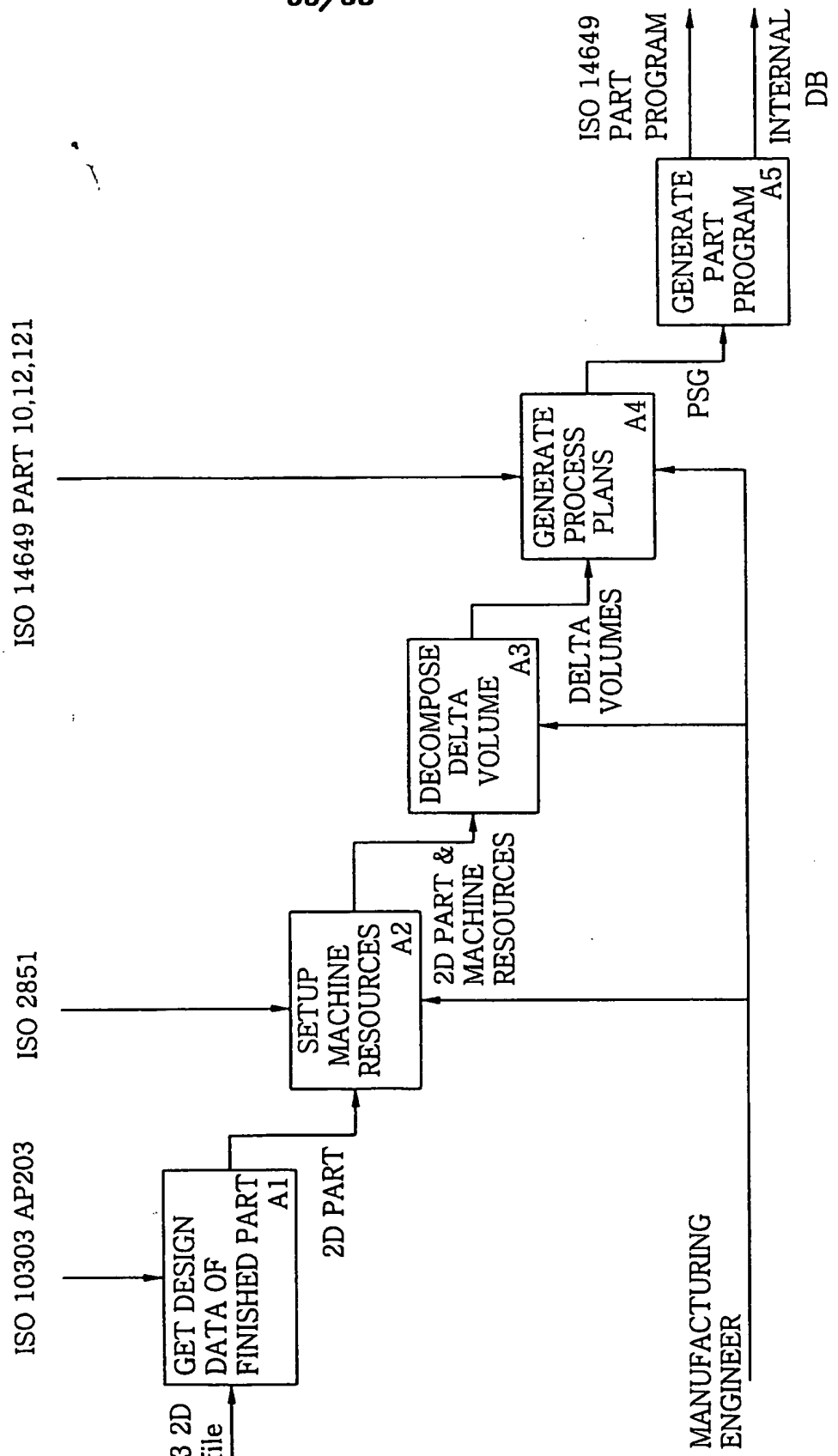

ISO 10303 AP203
ISO 2851
ISO 14649 PART 10,12,121
AP203 2D CAD file
GET DESIGN DATA OF FINISHED PART A1
SETUP MACHINE RESOURCES A2
DECOMPOSE DELTA VOLUME A3
GENERATE PROCESS PLANS A4
GENERATE PART PROGRAM A5
2D PART
2D PART & MACHINE RESOURCES
DELTA VOLUMES
PSG
ISO 14649 PART PROGRAM
INTERNAL DB
MANUFACTURING ENGINEER

FIG. 39

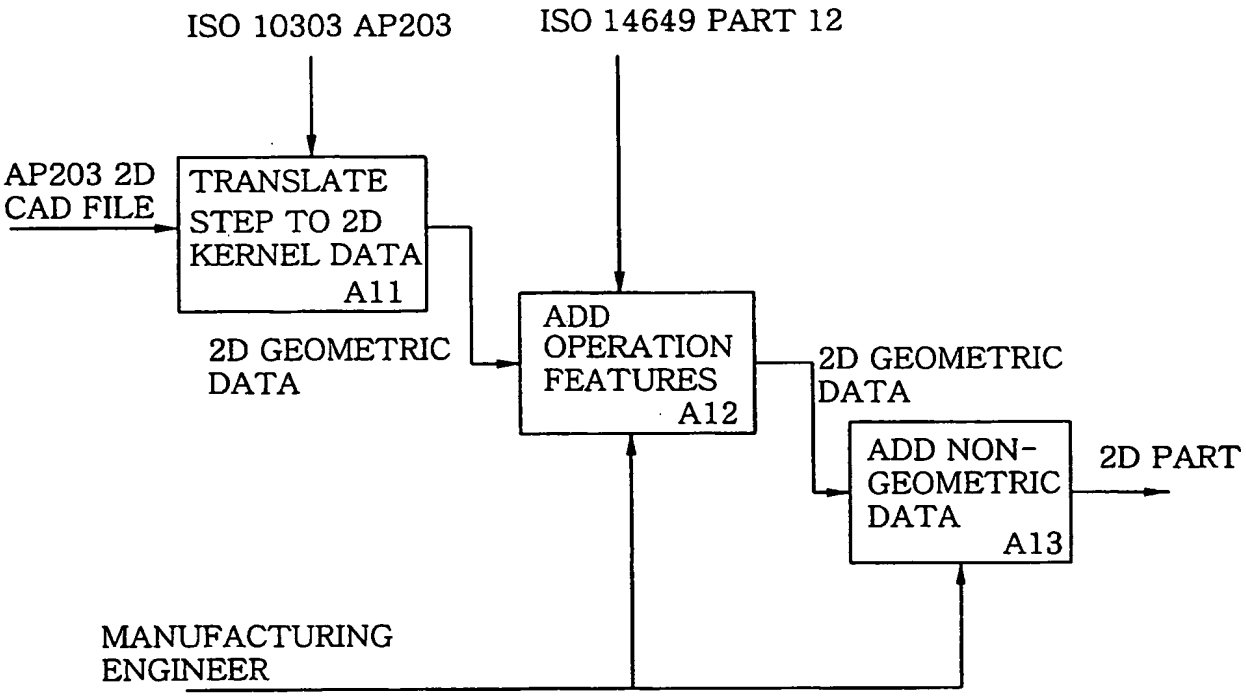

ISO 10303 AP203
ISO 14649 PART 12
AP203 2D CAD FILE
TRANSLATE STEP TO 2D KERNEL DATA A11
2D GEOMETRIC DATA
ADD OPERATION FEATURES A12
2D GEOMETRIC DATA
ADD NON-GEOMETRIC DATA A13
2D PART
MANUFACTURING ENGINEER

FIG. 40

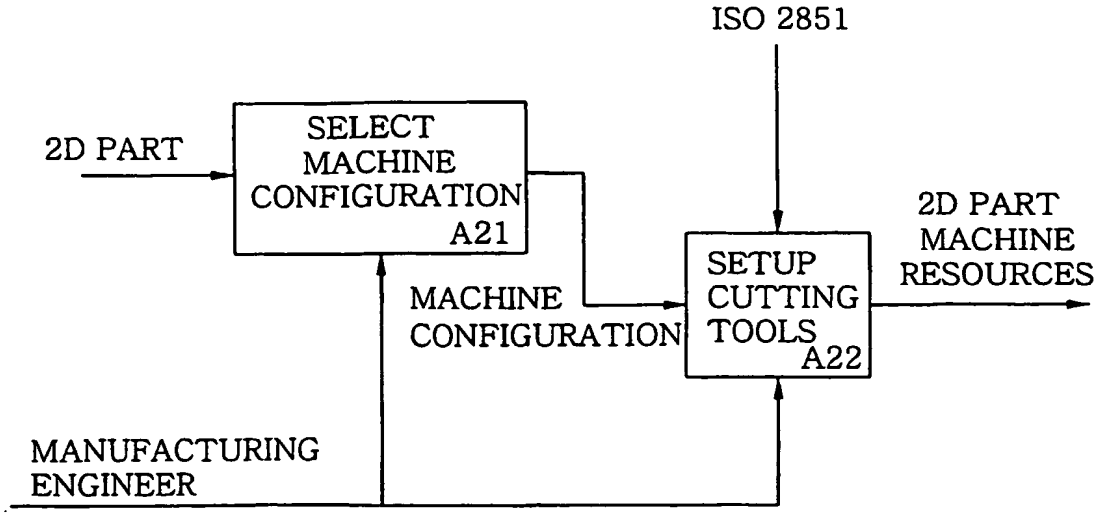

ISO 2851
2D PART
SELECT MACHINE CONFIGURATION A21
MACHINE CONFIGURATION
SETUP CUTTING TOOLS A22
2D PART MACHINE RESOURCES
MANUFACTURING ENGINEER

FIG. 41

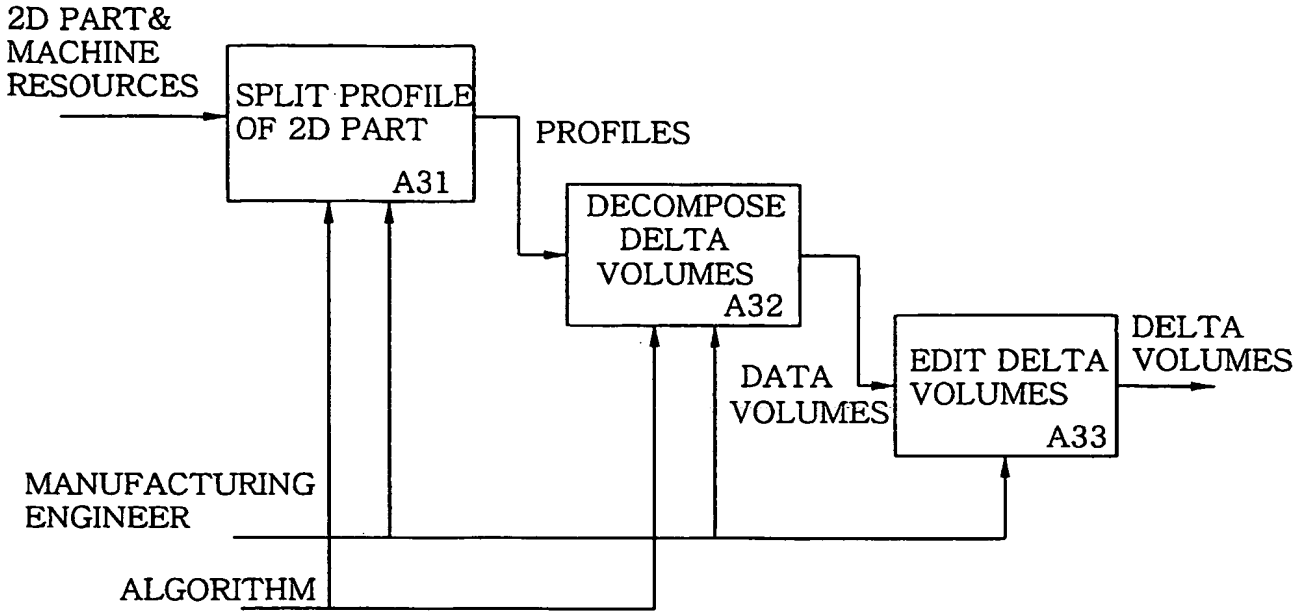

2D PART& MACHINE RESOURCES
SPLIT PROFILE OF 2D PART
A31
PROFILES
DECOMPOSE DELTA VOLUMES
A32
DATA VOLUMES
EDIT DELTA VOLUMES
A33
DELTA VOLUMES
MANUFACTURING ENGINEER
ALGORITHM

FIG. 42

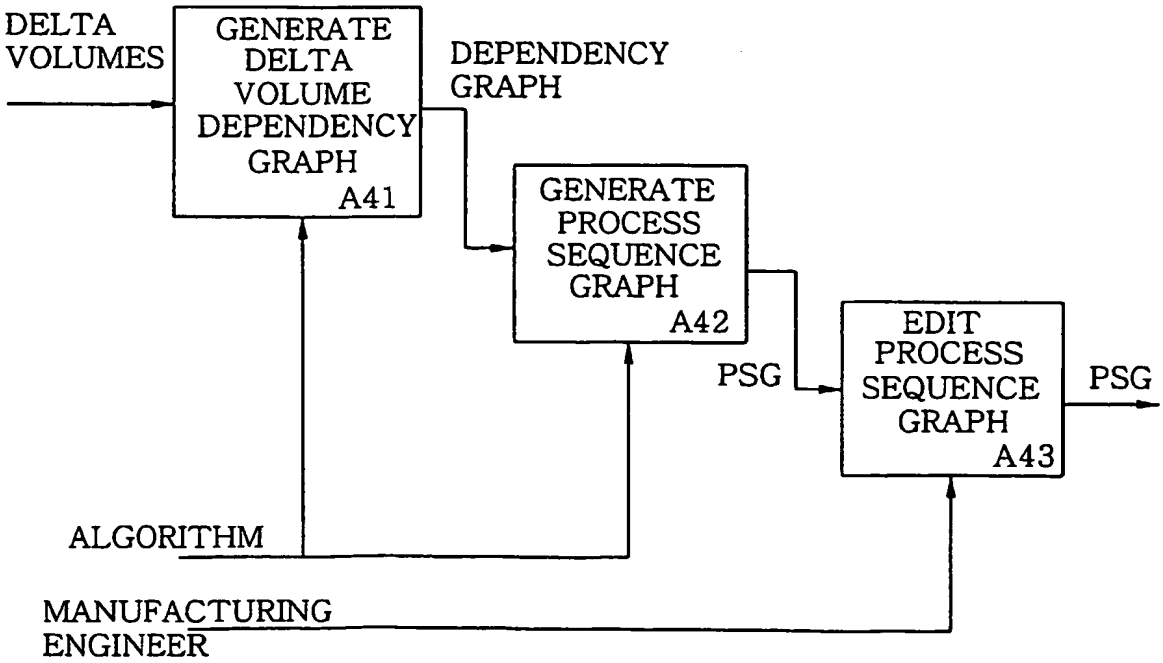
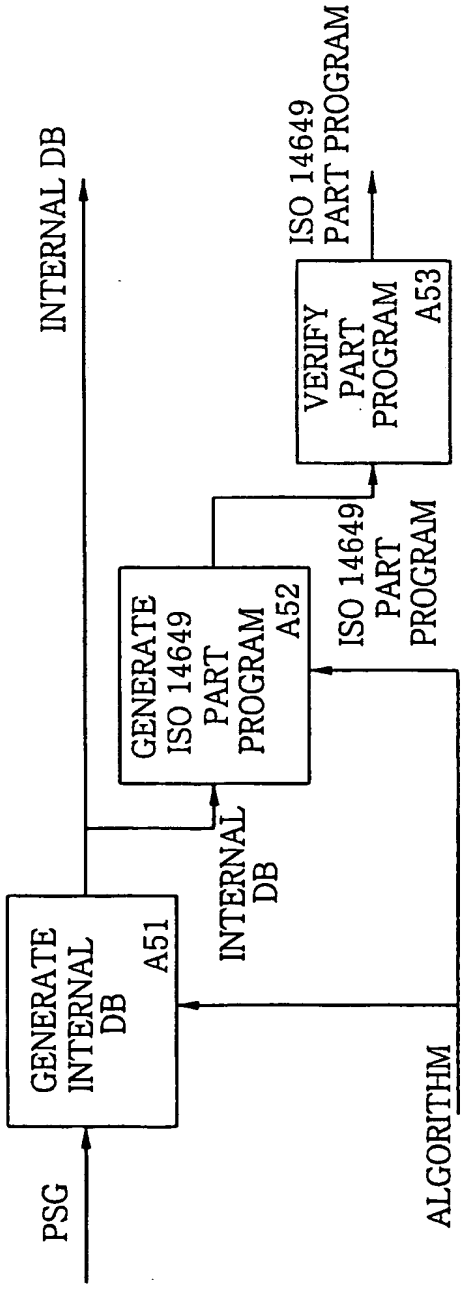

DELTA VOLUMES
GENERATE DELTA VOLUME DEPENDENCY GRAPH
A41
DEPENDENCY GRAPH
GENERATE PROCESS SEQUENCE GRAPH
A42
PSG
EDIT PROCESS SEQUENCE GRAPH
A43
PSG
ALGORITHM
MANUFACTURING ENGINEER

FIG.43


PSG
GENERATE INTERNAL DB A51
INTERNAL DB
INTERNAL DB
GENERATE ISO 14649 PART PROGRAM A52
ISO 14649 PART PROGRAM
VERIFY PART PROGRAM A53
ISO 14649 PART PROGRAM
ALGORITHM